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UPGRADING BASEMENTS FOR COMBINED NUCLEAR WEAPONS EFFECTS: PREDE--ETC(U)
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UPGRADING BASEMENTS FOR COMBINED NUCLEAR WEAPONS EFFECTS: PREDESIGNED EXPEDIENT OPTIONS II

SUPPLEMENT

Final Technical Report

July 1980

By: H. L. Murphy
Consulting Civil Engineer*

For: Federal Emergency Management Agency
Washington, D.C. 20472

Contract No. DCPA01-77-C-0227
FEMA Work Unit No. 1155C

SRI Project 6876

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This Supplement contains several applied examples in the upgrading area, as well as a description of the literature search for this research project.

Proj. 6876

MEMO

TO: Dr. M. A. Pachuta (COTR), DCPA

DATE: 10/2/78

FROM: H. L. Murphy, SRI Project Leader

LOCATION: 2N353

SUBJECT: Upgrading one-way slab over basement, West Pavilion, Stanford U. Hospital; results of existing structures evaluation for

CC: G. N. Sisson/J. E. Beck

Ref: Murphy, H. L., et.al., Upgrading Basements for Combined Nuclear Weapons Effects: Expedient Options, SRI Tech. Rpt. for DCPA, 5/76 (AD-A030 762); pp. 107-113.

1. As reported in referenced report, subject structure has an inherent blast resistance of about 10.7 psi (cover slab over basement), under existing structures evaluation techniques developed for DCPA by C. K. Wiehle and his colleagues. Referenced report also discusses expedient closing of basement apertures.

2. For the purposes of the current upgrading project, an analysis of the same slab has been run using the same techniques, but with a mid-span simple support line (either a wall,or steel beams supported by columns on some kind of spread footing (on top of the existing floor slab)); results were for assumptions of the existing slab being on fixed-fixed, simple-simple ~~and~~ propped-cantilever types of support, which yielded values of 23.2, 22.3 and 24.0 psi blast resistance - in short, the existing slab's blast strength would be doubled by an added support line at mid-span. Existing supports were found to be stronger than the slab's existing 10.7 psi strength (at least as strong as, that is); such supports would then be good for a doubling of the slab's strength by an added column line because the latter would be taking care of half of the doubled loading, or the same load as the existing 10.7 psi or so.

3. It should be remembered that existing structures evaluation strength values are intended to be median analysis values - this in contrast to design strength values that, even in blast design, are intended to offer say, 95-99% probability that the design strength will not be exceeded under a realistic test.

3-11-81 HLM

4. It is expected that similar analyses will be completed next week on the slab support beams/girders of both the Hamilton AFB Bldg. and Middlefield Underground Parking Garage of referenced report (pp. 75-95 and 97-106, respectively).

H. L. Murphy

A

Proj. 6876

MEMO

TO: Dr. M. A. Pachuta (COTR), DCPA

DATE: 10/18/78

FROM: H. L. Murphy, SRI Project Leader

LOCATION: 2N353

SUBJECT: Upgrading R/C support beams to exploit strength of R/C (2-way) slab over basement, Hamilton AFB Bldg. 424; results of existing structures evaluation for

CC: G. N. Sisson, DCPA
J. E. Beck, SRI

Ref: Murphy, H. L., et.al., Upgrading Basements for Combined Nuclear Weapons Effects: Expedient Options, SRI Tech. Rpt. for DCPA, 5/76 (AD-A030 762); pp. 75-95.

1. As reported in referenced report, subject structure has an inherent blast resistance of about 10.1 psi (cover slab over basement), under existing structures evaluation techniques developed for DCPA by C. K. Wiehle and his colleagues. Referenced report also discusses, among other things, expedient closing of basement apertures.

2. For the purposes of the current upgrading project, an analysis using the same techniques has been run on the support R/C beams that are alike on all two to four sides of the two-way R/C slab panels (over the basement), i.e., all sides other than those supported by walls. Using fixed-fixed type of support, the beams were evaluated as good for 3.6 psi (1 MT) at existing beam spans, which increased to 18.1 psi with beam spans of half the existing value,* i.e., with an intermediate beam support under each beam the existing slab's evaluation strength of 10.1 psi would be fully exploited.

3. It should be remembered that existing structures evaluation strength values are intended to be median analysis values - this in contrast to design strength values that, even in blast design, are intended to offer, say, 95-99% probability that the design strength will not be exceeded under a realistic test. 3-11-81 HLM

4. Because existing columns (and footings) were evaluated in referenced report as good for 16 psi (page 83), the intermediate supports at mid-span of beams (both ways) could be engineered supports carrying the load back to the existing columns (e.g., cable suspension type supports). The intermediate supports could be, of course, expedient type(s) with provision for spreading their footing load on the existing floor slab.

H. L. Murphy

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* Propped-cantilever support conditions were assumed for evaluation of the beams with expedient mid-span supports; tributary area supported was, of course, reduced to 1/4 of the existing case.

SRI Proj. 6876

MEMO

TO: Dr. M. A. Pachuta (COTR), DCPA

DATE: 10/18/78

FROM: H. L. Murphy, SRI Project Leader

LOCATION: 2N353

CC: J. E. Beck, SRI
G. N. Sisson, DCPA

SUBJECT: Upgrading R/C joist and girders to exploit strength of of R/C slab over underground parking garage (Middlefield); results of existing structures evaluation for

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Ref: Murphy, H. L., et.al., Upgrading Basements for Combined Nuclear Weapons Effects: Expedient Options, SRI Tech. Rpt. for DCPA, 5/76 (AD-A030 762); pp. 97-106.

1. As reported in referenced report, subject structure has an inherent blast resistance in its cover slab of more than 30 psi, under existing structures evaluation techniques developed for DCPA by C. K. Wiehle and his colleagues. Referenced report also discusses, among other things, the expedient scheme of providing mid-span supports under subject slab support members, as well as the expedient closing of all apertures.

2. For the purposes of the current upgrading project, analyses using the same techniques were run on the slab support members, joists and girders, with added mid-span supports applied under expedient conditions to each of the two member types. Assuming fixed-fixed support conditions, the joists showing the weakest blast resistance (which applied to most of the joists in the garage) were evaluated as good for 3.3 psi (with current evaluation program; referenced report shows 3.6 psi under an earlier version of the evaluation program), and the girders were similarly evaluated as good for 3.3 psi (3.5 psi earlier). With the addition of intermediate girder lines, supporting the joists at mid-span, joist strength shows an evaluation value of 10.4 psi; and with additional columns to provide mid-span support to each girder, they showed an evaluation value of 19.7 psi.* Thus, mid-span supports under joists and girders were inadequate to fully exploit the inherent strength of the slab, which was stronger than most because of the need for design to meet the punching shear stresses used for wheel loads of parked cars/trucks on the garage overhead slab.

3. Several trial combinations of added joist and girder supports were evaluated:

	Joist			Girder			Supports (added)	
Case	Span	Area	PSI	Span	Area	PSI	Joist	Girder
1	Full	Full	3.3	Full	Full	3.3	none	none
2	1/2	1/2	10.4	Full	1/2	6.7	Mid-sp.	none
3	"	"	"	1/2	1/4	19.7	"	Mid-span
4	1/3	1/3	13.1	Full	1/3	9.6	3rd-sp.	none

4. Columns/footings would be adequate for Cases 1 and 3 (referenced report page 100) but would have to be checked for Cases 2 and 4.

5. It should be remembered that existing structures evaluation strength values are intended to be median analysis values - this in contrast to design strength values that, even in blast design, are intended to offer, say, 95-99% probability that the design strength will not be exceeded under a realistic test.

3-11-81
HLM

H. L. Murphy

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* Propped-cantilever support conditions were assumed for evaluation of both joists and girders with expedient mid-span supports.

6876

SRI

MEMO

TO: G. N. Sisson, DCPA

DATE 6/28/78

FROM: H. L. Murphy, SRI Project Director 6876

LOCATION:

SUBJECT: Van entrance door to earth-mounded, "host" area, R/C box-like shelter building; comments on

CC: Dr. M. A. Pachuta (DCPA)
C. K. Wiehle, SRI
E. E. Pickering, SRI

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1. This memo summarizes and supplements the information given to you today by phone re ideas for subject door.

2. Enclosure 1 goes through one solution in some detail, because there were some points I wanted to check out, for sensitivity, accuracy, etc. In brief, this solution calls for two "wingwalls" spaced at about 10 ft and with top of wall sloping from structure roof to ground level at about 1:1 or $1\frac{1}{2}$:1 (horiz. to vertical). Assumptions are p_{so} = 10 psi, from which p_r = 23 psi; W = 1 Mt; total mass thickness (say, wood and earth) = 300 psf (which adds $(300/144)x(5/6) \approx$ 1.8 or, say, 2 psi), making p_r = 25 psi and increases the stagnation pressure by 2 psi also. Assuming mu = 3 (ratio of expected max. deflection to elastic) gives the 5/6 just used, if load is a step pulse, a good first trial; thus, $p_{dm}=p_r=25$.

Entering Figures B-1A and B, pages 22 and 23, Reference 4, with Clear Span of 10 ft (120 in.) shows that a "lower strength" 2x8 is good for 16 psi (Fig. B-1A) and a "higher strength" 2x8 is good for $28\frac{1}{2}$ psi (Fig. B-1B). To get p_{dm} just = 25, a stress-graded 2x8 must have allowable stresses of 1540 (or better) for F_b and 82 psi (or better) for F_v - see Enclosure 1, Sheet 3. Required bearing length at each end: $L' = 1800/F_{c\perp}$ (for example, 5 in. if $F_{c\perp}$ = 360 psi (or better), etc.).

If allowable stresses (see Enclosure 2) for an available wood are lower than those needed, resort to 2x10s should care for the problem; check for flexure and horizontal shear, using formulas on Sheet 2 of Enclosure 1, where formula for required bearing length is also furnished.

Assuming availability of stress-graded wood species that just meet the requirements above (1540 and 82 psi for F_b and F_v, respectively), the Beck modification of the Newmark Beta Method was used (on the just-in-balance results above (p_r=25, and stresses of 1540 and 82 both multiplied by 4 for blast design of course)), to find out just how conservative the step pulse load with mu=3 is in this case.

A loading was constructed, using zero-rise time to p_r then dropping to stagnation pressure (p(t)+q(t)) in a clearance time t_s=3S/U, where U was picked from Ref. 1 and S was taken as the ramped earth slant height, approx. 36 ft (20 ft vert., 30 ft horiz.). Results gave mu=1.64 To check the sensitivity of the assumed S (i.e., slant height), t_s was checked at ± 50% which gave mu= 1.30 (-50%) and 1.84 (+50%); conclusion was, not very sensitive. These calculations all used dynamic load-mass factors of 0.78 (elastic) and 0.66 (plastic) (Ref. 4; p. 11-24), as they should have. Check calculations using a step pulse loading (to see if mu = 3 resulted) revealed that, if the K_{LM} factors were used, mu=2.84 resulted; however, as long as the two K_{LM} factors were taken as equal (or ignored, meaning they were set equal to one), then mu=3 resulted. (The latter results also gave us a check on a freshly written (for another project) computer program for Beta Method calculations.)

These checks made me feel much better about: Use of slant height for a clearing distance on an aboveground structure; use of a step pulse with mu=3, at least for <u>reflected</u> blast-loaded structures. ~~(I~~ Otherwise, still question mu=3, as now do those who prepared Ref. 3, wherefrom came the value for use with wood, originally; we all want/need correlated static and dynamic tests in these wood areas.)

3. Alternate approaches to this closure problem are outlined on the next sheet - we will further develop any one or all of them, should you desire it; meanwhile subject is dropped, per your wishes. Best personal regards, Murph

Appended Sheet to memo of 6/28/67 to G. N. Sisson from H. L. Murphy

Subject: Van entrance door to earth-mounded, "host" area, R/C box-like shelter building; further comments/ideas on

A. Your idea of a vertical entrance door, with soil mounded against it for radiation protection, offers several approaches to subject door and expedient closures, and will probably be more effective (in terms of ease of application and/or cost in man-hrs and $) than the sloping closure in the cover memo. Most important of the items is that the closure "height" changes from approx. 36 ft to, say, 14 or 15 ft.

a. With 10 ft between "wing walls" a R/C door-stop, say, 6 in. wide on each side of the truck opening would need to be sufficiently strong to take the blast loading reaction from the closure.

b. With "a." done, a whole host of possibilities exist:

1. 2x8s (or 2x10s), a la the memo discusssion, could be stacked up flatwise, handled either as individual wood members, or nailed together in 3 or 4 to a bundle to facilitate handling - with soil pushed into place outside, keeping pace with the placing of the wood members and holding them in place.

2. Plywood Stressed-Skin Panels (PSSPs), Ref. 2 pp. 8-20, can be used with a clear span of 9 ft (108 in.), but would have to have the span reduced into halves or thirds by vertical supports (steel shapes), perhaps hinged at the ceiling and lowered/anchored at time of use. This intermediate support idea could be also applied to reduce the size of the 2x8s in the scheme of the preceding paragraph.

3. Channel tracks could be mounted just outside the door-stop of para "a." above, cutting through to continue along the interior/ceiling. Built-up steel panels, similar to but stronger than the PSSPs, could be hinged to one another to form a continuous door raised/lowered by a man-operated chain hoist; the panels could be heavy enough to span the full 9 ft opening, or have spans reduced in a similar manner to that suggested in para 2 just above.

B. Perhaps the common denominator here is to have a normal-use closure, even if used infrequently, serve also as the emergency closure - whether or not it is kept lighter by including provision to expediently install vertical supports (as many as desired) that would shorten the door's span/increase its strength for the transition from normal-use to blast-use.

REFERENCES

1. Glasstone, S., and P. J. Dolan, The Effects of Nuclear Weapons, 3rd ed., U. S. Departments of Defense and Energy, 1977.

2. Murphy, H. L., Upgrading Basements for Combined Nuclear Weapons Effects: Predesigned Expedient Options, SRI International, Menlo Park, CA 94025, for U. S. Defense Civil Preparedness Agency, October 1977. (AD-A054 409)

3. Newmark, N. M., Design of Openings for Buried Shelters, for U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, July 1963.

4. Murphy, H. L., et al., SLANTING IN NEW BASEMENTS FOR COMBINED NUCLEAR WEAPONS EFFECTS: A Consolidated Printing of Four Technical Reports, SRI International, for U. S. Defense Civil Preparedness Agency, October 1975. (AD-A023 237)

6876 GNS: "Host" area housing for Comm. trailer van 5/12/78 HLM ①

Refs

Earth-mounded R/C structure; can have expedient (entrance) closure matl's stored there in advance.

Use $p_{so} = 10$ psi from 1 Mt. weapon ("host" area) (contact surface burst)

Assume earth cover sufficient to bring total mass thickness = 300 psf.

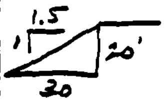
Assume cover needs 1.5:1 (or flatter) slope (note bank construction usage is horiz: vertical ratio, as in hiway, RR & airport practice & all C.E.) in fact 1.5:1 or 2:1 should probably be a soil-cement mixture — and, of course, should be stream-lined at toe and top of bank.

Will use 1.5:1 for this example, because reflection factor is higher for steeper banks: At 1.5:1 (56° betw. blast wave front, assuming Mach region, and bank surface. (Diff. betw. ratios for banks @ 1.5:1 & 2:1 is small).

$p_r : p_{so} = 2.3$ [for $p_{so} = 10$ psi] [and 56° angle of incidence] 1: p.123

$\therefore p_r = 23$ psi

Clearance time: DNA's DICE-THROW event (HE) checked the theory that clearance distance (on a sloping roof a little steeper than 45° to horiz.) equal to the ~~vertical projection~~ length of the exposed bank be used for calculating clearance time (where bank width is much greater, at least). (oral commun- J.R. Rempe)



$\therefore$ Use, say, 36 ~~20~~ ft. (~~length~~ slant length, in this case)

5/16/78

Loading: $S = \cancel{20}\ 36$ ft $\quad p = 10$ psi $\quad p_r = 23$ psi 1: p.136-8

$U = 1400$ fps 1: p.98

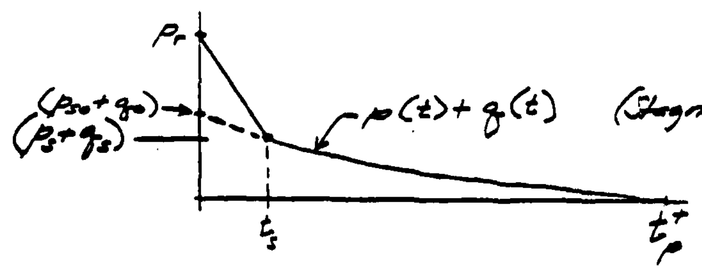
Range ≈ 10500 ft (1050 for 1 kt.) 1: p.115

$q = 2$ psi 1: p.117

$t_p^+ = 2.4$ sec. $\quad t_q^+ = 3.5$ sec. 1: p.119

$t_s = 3S/U = 3\,(\cancel{20}\ 36)/1400 = \cancel{0.043}\ 0.077$ sec. 1: p.100-1

$p_s = p(t_s) + C_d\, q(t_s)$ $\quad C_d = 1$ for "front face" 1: p.127 "



(Ignore remainder of t_q^+ — too small $q(t)$ and $p(t)$ is negative for awhile).

ENCLOSURE 1

One closure technique: Wood (stress-graded) members stacked (for edgewise strength) on R/C wing walls, one on each side of truck entrance. — say with a sheet of plastic for covering, then soil(cement) cover, for a total mass thickness = 300 psf (≐ 2.1 psi) 2: Ref.4 (on p. 28).

Use L = clear span (in.) = 120 (truck trlr width = 96)

<u>Wood member (stress-graded) resistance function</u>: 2: App. B

$F_{db} = 4F_b \quad F_{dv} = 4F_v \quad F_{dc\perp} = F_{c\perp} \quad \mu = 3 \left[= \frac{x_m}{x_e} \right]$ " p. B-1

$q_b = 2F_b (d/L)^2 / (3c)$ (flexure or bending) " p. 6-109

where $c = 1/8$ for single span on simple supports

$q_v = 8F_v d / (3c'(L-2d))$ (horiz. shear) " "

where $c' = 1/2$ (ditto).

After any design is completed as above — weaker of q_b and q_v controls — call it q. [But remember it differs from the q (dynamic pressure) of the <u>loading</u> development above.]

Req'd bearing length at <u>each</u> <u>end</u> of wood beam, L' is:

$$L' = q L c' / F_{c\perp}$$ " p. 6-110

where c' is as above, and q is the smaller of q_b and q_v above.

Selected μ [= 3] may be a little high — but it will be examined later, below. 2: p. 6-101 ¶3

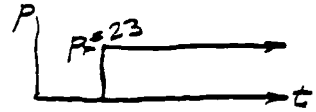
To complete a formal resistance function, one needs the yield deflection, in this case at mid-span:

$$x_e = \frac{5}{32} \frac{qL^4}{Ed^3}$$ 3: p. 161

where E = elastic modulus, // grain (psi). Values in: 2: Ref. 4 (on p. 28)

Design Solution #1:

Assume step pulse loading (zero rise-time to a load of infinite duration):



Then: $p_{dm} = q\left(1 - \frac{1}{2\mu}\right) = \frac{5}{6}\, q$

Convert mass thickness, 300 psf, to a pseudo-applied dynamic load and add to p_r:

$$\Delta p_{dm} = \frac{5}{6} \times \frac{300}{144} \approx 2 \text{ psi}$$

$$\Sigma p_{dm} = p_r + \Delta p_{dm} = 23 + 2 = 25 \text{ psi}$$

Use charts and find that 2x8s, higher strength, at $L = 120$ in. are good for:

$p_{dm} = 28$ psi ($L' = 5.5$ in.) — 2: p.23

and lower strength are good for:

$p_{dm} = 16$ psi ($L' = 5.0$ in.) — 2: p.22

Underlined is design solution #1.

Charts were developed using a step pulse and equations on the preceding sheet. — 2: p.22-3

We can use the q_v and q_b equations to find a pair of F_v and F_b values that just satisfy the $p_{dm} = 25$ psi and $L = 120$ in. on 2x8s:

$$q_b = 2F_b\left(\frac{7.25}{120}\right)^2 \Big/ (3/8) = q_v = 8F_v\,(7.25) \Big/ \left(3 \times \tfrac{1}{2}(120 - 14.5)\right)$$

$$F_b / F_v = 18.827$$

$$q_b = q_v = \frac{6}{5}\, p_{dm} = \frac{6}{5} \times 25 = 30 \text{ psi}$$

$$F_b = \frac{30}{2}\left(\frac{120}{7.25}\right)^2\left(\frac{3}{8}\right) = 1541 \text{ psi}$$

$$F_v = F_b / 18.827 = 82 \text{ psi}$$

and E can be taken proportionally to the F_b above & F_b values on charts (975 and 1750 psi) vs. the E's for lower and higher strength members: 1.1 and 1.8×10^6 psi: — 2: p.22-3, 2: p.C-5

$$E = \left[\left(\frac{566}{775}\right) 0.7 + 1.1\right] \times 10^6 \text{ psi} = 1.61 \times 10^6 \text{ psi}$$

Design Solution #2 (Detailed method; find closer μ value)

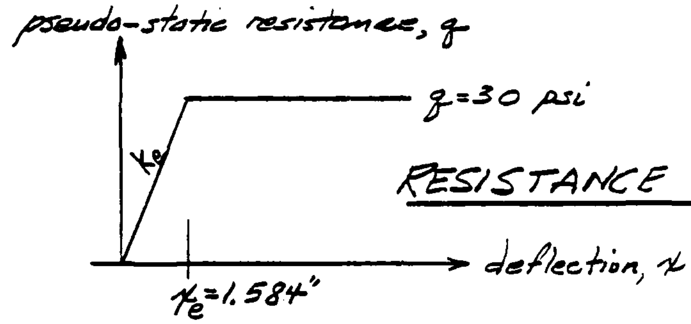
$d = 7.25"$ $\quad l = 120"$ $\quad p_r = 23 + 2$ (for mass) $= 25$ psi

$F_b = 1541$ psi $\quad F_v = 82$ psi $\quad E = 1.61 \times 10^6$ psi

$q = q_b = q_v = 30$ psi peak resistance (Sheet 2)

$x_e = \frac{5}{32} \times \frac{30 \times 120^4}{(1.61 \times 10^6)\ 7.25^3} = 1.584"$ (carrying decimal places for convenience, NOT to imply degree of accuracy). (Sheet 2)

$k_e = 30/1.584$ (elastic stiffness)



RESISTANCE FUNCTION

LOADING FUNCTION (Bottom of Sheet 1) (cont'd)

Fit parabola to 3 known points of stagnation pressure curve: 4: p.6-82

	t (x)	p (y)	
		p_{so} q_o equiv. mass π.	
$x_1 y_1$	0	$10+2+2=14$ psi	(Sheets 1 & 3)
		$p = 12$, $q = 2$ (initial values for stagnation pressure curve)	
$x_3 y_3$	2.4	0	
$x_2 y_2$	1.2	3.74	

t_p^+: $1.2 \div 2.4 = 0.5$; $0.27 \times 12 = 3.24$ (Sheet 1)

t_q^+: $1.2 \div 3.5 = 0.34$; $0.25 \times 2 = 0.5$; 3.74 psi — p.100-1

$$h = x_2 - x_1 = x_3 - x_2 = 1.2$$

$$A = y_1 = 14$$

$$B = (y_2 - A)/h = (3.74 - 14)/1.2 = -8.55$$

$$C = (y_3 - A - 2Bh)/(2h^2) = (0 - 14 + 2 \times 8.55 \times 1.2)/(2 \times \overline{1.2}^2)$$

$$C = 2.26389$$

$$p = 14 - 8.55(t - \underset{0}{t_1}) + 2.26389(t - t_1)(t - t_2)$$

$$(t^2 - \cancel{t_1 t} - t_2 t + \cancel{t_1 t_2}) \quad t_1 = 0,\ t_2 = 1.2$$

$$p = 14 - 8.55t + 2.26389t^2 - 2.71668t$$

$$p = 2.26389t^2 - 11.26668t + 14$$

	t	p(t)+q(t)
	[0	14]
t_s (p_s+q_s)	0.077	13.146
"	0.039	13.564
"	0.116	12.724
	0.15	12.361
	0.3	10.824
	0.6	8.055
	1.0	4.997
	1.5	2.194
	2.0	0.522
	2.4	0

$\boxed{t = 0:\ p_r = 25 \text{ psi (zero rise-time) dropping at } t_s \text{ to } p_s + q_s}$ (Sheet #1)

Trial #1 t_s (Sheet #1)
" #2 $t_s - 50\%$
" #3 $t_s + 50\%$

[Trial #4: Stop pulse at $p = 25$]

Details for Loading Function shown on Sheet 1

ENCLOSURE 2

TABLE 1

Allowable Unit Stresses – Structural Lumber

Supplement

to

1973 EDITION

of

NATIONAL DESIGN SPECIFICATION

for

STRESS-GRADE LUMBER and ITS FASTENINGS

Out-of-date there is a new 1977 edition

Recommended by

NATIONAL FOREST PRODUCTS ASSOCIATION

1619 Massachusetts Avenue, NW Washington, D. C. 20036

April 1973

Revised November 1974

NOTE: This Supplement provides data on working stresses determined in accordance with American Society for Testing and Materials Designations D245-70 "Methods for Establishing Structural Grades and Related Allowable Properties for Visually Graded Lumber" and D2555-70 "Methods for Establishing Clear Wood Strength Values."

Literature Search

The literature search, which completes the period up to January 1978 in this ongoing work,* included both a computerized and a manual search. The computerized literature search used the services of the Lockheed DIALOG system, which provides access to over 80 databases. Two of these databases, NTIS and Compendex, were searched for the current effort. A short description of these databases follows:

A. The NTIS database (prepared by the National Technical Information Service, Springfield, Virginia) is the computerized version of Government Reports Announcements/Index. It consists of government-sponsored research, development and engineering, plus analyses prepared by federal agencies, their contractors or grantees. It is the means through which unclassified, publicly available, unlimited distribution reports from such agencies as NASA, DDC, AEC, HEW, HUD, DOT, Department of Commerce, and some 240 other units are made available for sale (covers 1964 to present).

B. The Compendex database is the machine-readable version of the Engineering Index (Monthly/Annual), which provides the engineering and information communities with abstracted information from the world's significant engineering and technological literature. The EI database provides worldwide coverage of approximately 3500 journals, publications of engineering societies and organizations, papers from the proceedings of conferences, and selected government reports and books. (1970 to present)

The manual search covered Technical Abstracts Bulletin, the monthly index of Defense Documentation Center (DDC) documents, with the search period from 1971 to the present (Jan. 1978). The DDC receives all Department of Defense reports, both classified and unclassified; unclassified and declassified reports eventually become part of the NTIS system also. The search period covers those issues of the index still under classified status due to their contents. This index was not covered in previous searches.

Use of the DIALOG system allows an entirely new and rapid method of conducting a literature search. While manual searching relies on descriptors† alone, computerized searching covers several fields - descriptors, identifiers, title, and abstract - to locate the key words chosen by the searcher. While manual searching would not miss references entirely devoted to the subject area, computerized searching will find those references with only a section devoted to the subject area, if it is described

* Previous literature searches, carried out in the first and second phases of the work, covered the period from 1955 to Sept. 1976. By its nature the computerized search also covered part of this period.

† Descriptors are key words chosen by the author from an authorized list to describe his report. Identifiers are key words not on the authorized list but which the author uses to supplement the descriptors. In Government Reports Index, reports are indexed under major descriptors.

in the abstract. Whereas manual searching requires days or weeks of effort, computerized searching is carried out in minutes. References can be typed out immediately online, or printed offline and received by mail within 4 days at reduced expense.

In computerized searching like terms are combined into sets which, when combined with or modified by other sets, result in a list of references covering all aspects of the subject area. Key words chosen for the NTIS and Compendex searches are as follows:

Group I

Set (A): construction, building(s), structure(s), shelter(s)
Set (B): subsurface, underground, fallout
Set (C): basement(s)
Set (D): blast(s), airblast(s), nuclear bombs, explosion(s), overloading, dynamic loading, civil defense, civilian defense, national defense

Group II

Set (E): beam(s), slab(s), column(s), joist(s)
Set (F): upgrade(ing), strengthen(ing), rehabilitate(ing)(ion)

Group III

Set (G): timber, lumber, wood
Set (H): test(s)(ing)
Set (I): static, dynamic

The NTIS search produced 30 references in Groups I and II; Group III has not been received. The Compendex search produced 10 references in Groups I and II. These 40 references are to be reviewed by the Project Leader.

For the manual search of the TAB index the following descriptors were chosen: civil defense, shelters, and structures. This search produced 11 references, which are also to be reviewed by the Project Leader.